

Microstructure Design of Advanced Multi-Domain Magnetic Materials under Applied Fields

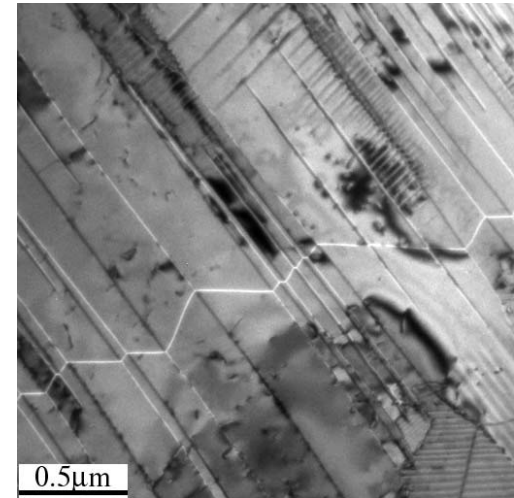
Khachaturyan (Rutgers), Laughlin(CMU) and Wang (OSU), DMR (FRG) Award #9905725

Magnetic domain characterization

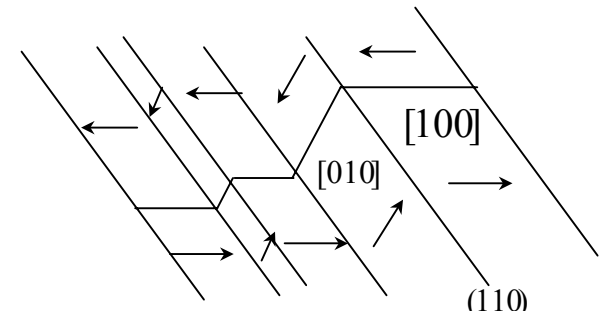
- Annealing experiments: the Fe55at%Pd alloy was annealed both above and below the Curie temperature (T_c).
- Microstructure: both polytwinned structure and tweed structure have been observed. Lorentz microscopy imaging techniques are used to image the magnetic domains.
- Trace analysis was developed to determine the surface orientation of the magnetic domain images; to analyze the magnetization direction and to determine the sample thickness.
- This trace analysis can be applied to many magnetic systems during Lorentz imaging. It provides crystallographic information without taking diffraction pattern and therefore without altering the magnetic domain pattern.



L. Wang, Z. Fan, D. E. Laughlin, "Trace Analysis for Magnetic Domain Images of $L1_0$ Polytwinned Structure," submitted to *Scripta Materialia* (2002).



Magnetic domain wall image, the black and white lines are magnetic domain walls.



Arrows indicate magnetization directions.

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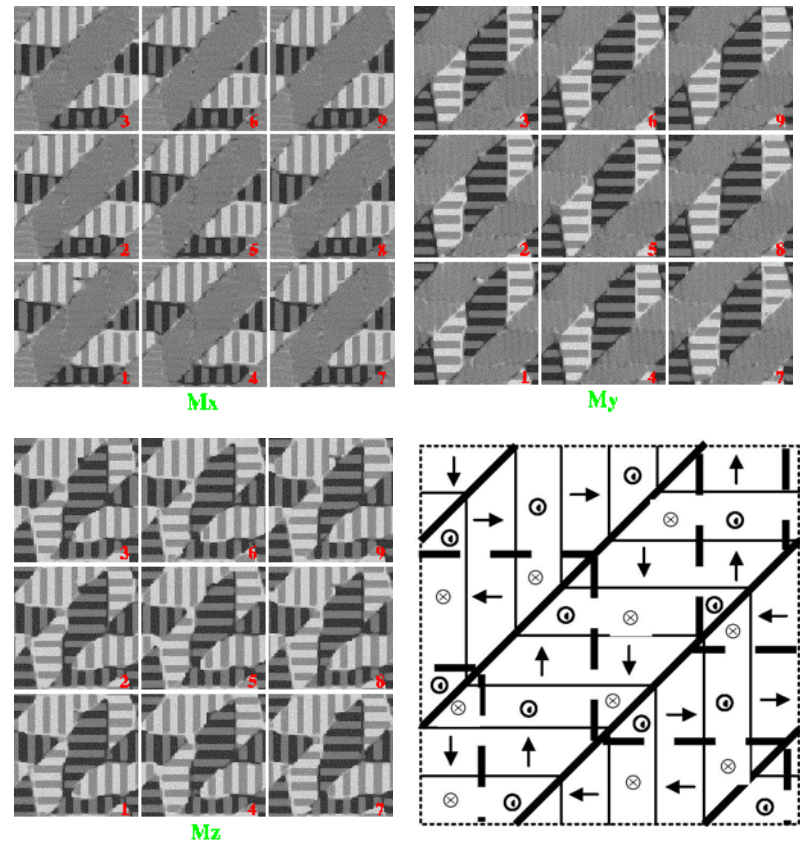
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Microstructure Modeling

- According to experimental observations, the coupling between magnetic domain structure and polytwinned microstructures in FePt thin films is studied both theoretically and using computer simulations.
- Multilevel hierarchy in the magnetic domain structures is predicted, which agrees well with the observations.
- Parameters controlling the magnetic domain structure and domain wall orientations are analyzed.
- Insight gained to the design of specially tailored microstructures with improved magnetic properties.



A. Kazaryan, Y. Wang, Y.M. Jin, Y.U. Wang, A.G. Khachaturyan and D.E. Laughlin, "Development of Magnetic Domain Structure in Highly Anisotropic Magnetic Thin Films of Polytwinned Microstructure" (submitted to *Journal of Applied Physics*, 2002).



Simulation prediction of complex magnetic domain structure and the corresponding schematic drawing in hard ferromagnetic thin films with polytwinned microstructure

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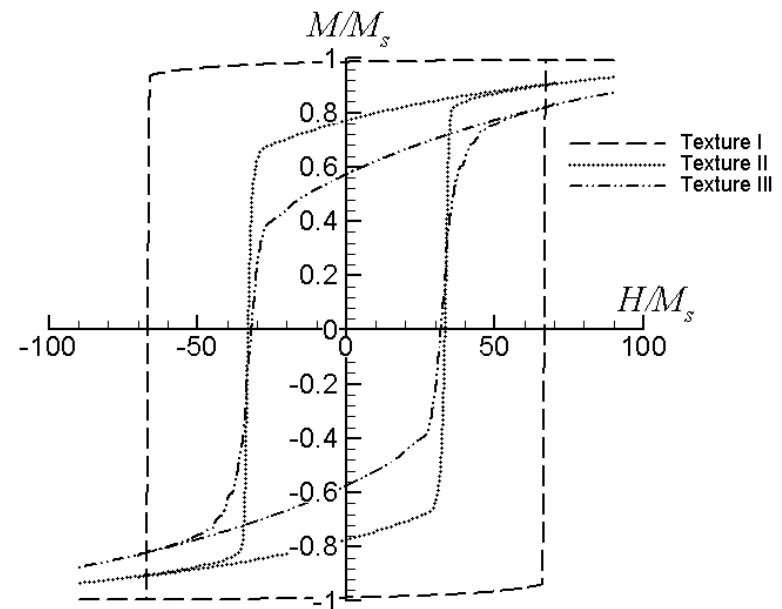
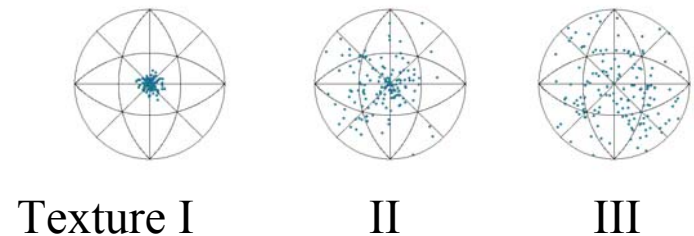
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Structure-Property Relation

- Three different grain textures in hard magnetic thin films are simulated.
- Different magnetic properties are observed.
- Detailed spatial-temporal evolutions of magnetic domains reversal are recorded.
- Mechanisms controlling structure-property relation are revealed.
- Insight gained for advanced magnetic material design.



Y.M. Jin, Y.U. Wang, A. Kazaryan, Y. Wang, D.E. Laughlin, and A.G. Khachaturyan, "Magnetic Structure and Hysteresis in Hard Magnetic Nanocrystalline Film: Computer Simulation" (submitted to *Journal of Applied Physics*, 2002).



Magnetic hysteresis loops
of different textures

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Structure-Property Relation

- Two main mechanisms are associated with grain textures: nucleation and domain wall movement.
- Nucleation and domain wall movement exhibit different dependences on grain textures.
- It is possible to design magnetic property by tailoring grain texture.

Education:

Two graduate students (Yongmei M. Jin and Lisha Wang, Ph.D. candidates) and two postdoctoral research associate (A. Kazaryan and Yu U. Wang) have participated in this research.

